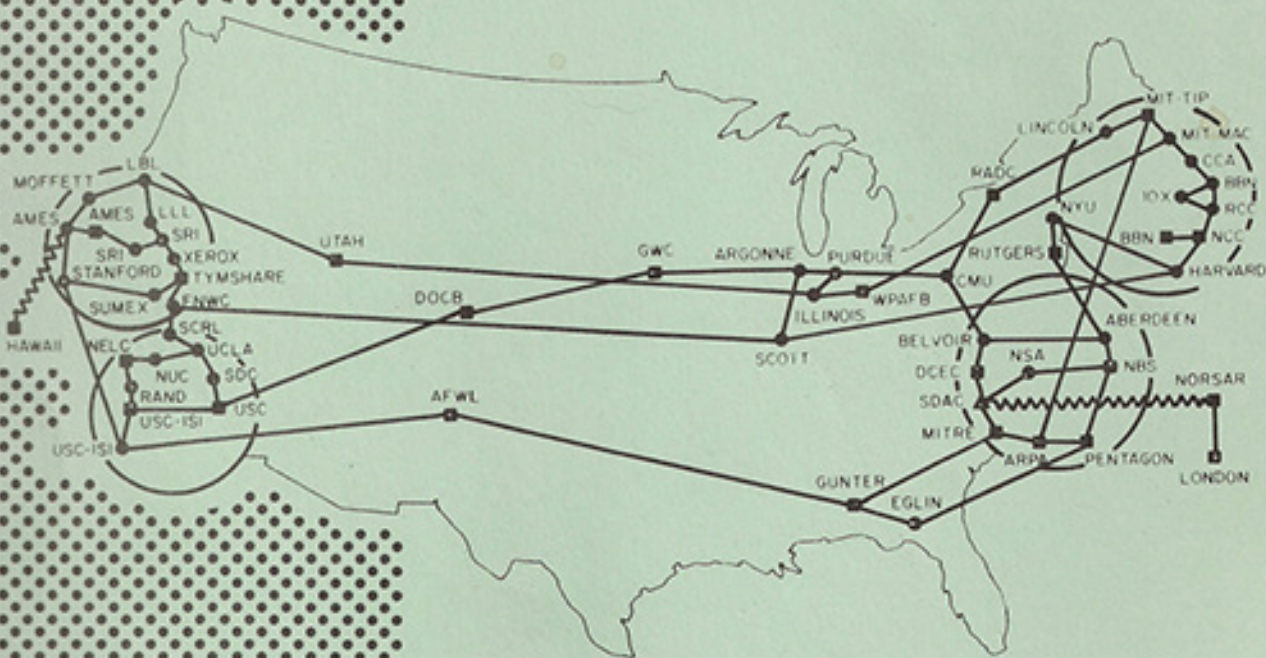




ARPANET INFORMATION BROCHURE



DEFENSE
COMMUNICATIONS
AGENCY

SUMMARY

ARPANET is an operational, resource sharing inter-computer network linking a wide variety of computers in CONUS, Hawaii, Norway, and England. Its communications system introduced the revolutionary technique of "packet switching" where each message is broken up into small packets and each packet is switched to its destination over the quickest communications path available at any given instant. ARPANET was originally designed under a research and development program by the Defense Advanced Research Projects Agency in 1969. Management responsibility of the network was transferred to Defense Communications Agency on July 1, 1975.

This brochure provides a general description of the ARPANET and defines the policies and procedures governing its use. Additional information for prospective users of ARPANET and extra copies of this brochure are available from:

Defense Communications Agency
ATTN: Code 535
Washington, D.C. 20305
Telephone Number (202) 692-6175/6176
AUTOVON 222-6175/6176
ARPANET Mailbox: DCACode535@ISI

AUGUST 1976

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1. PURPOSE

The purpose of this brochure is to provide a description of the ARPANET and the policies and procedures for its use.

2. INTRODUCTION

The ARPANET is an operational, resource sharing inter-computer network linking a wide variety of computers at Defense Advanced Research Projects Agency (DARPA) sponsored research centers and other DoD activities in CONUS, Hawaii, Norway, and England. The ARPANET originated as a purely experimental network in late 1969 under a research and development program sponsored by DARPA to advance the state-of-the art in computer interconnecting. The network was designed to provide efficient communications between heterogeneous computers so that hardware, software, and data resources could be conveniently and economically shared by a wide community of users. As the network successfully attained its initial design goals, additional users were authorized access to the network. Today, the ARPANET provides support for a large number of DoD projects and other non-DoD government projects with an operational network of many nodes and host computers. (See enclosures 1 & 2).

Following the successful accomplishment of initial ARPANET design goals and the expansion of the network, it was considered appropriate to transfer the responsibility for operation of the ARPANET from DARPA to the Defense Communications Agency (DCA) in July 1975.

3. DEFINITIONS

For ease of understanding the ARPANET and the policies governing its use; the following definitions are provided:

a. Interface Message Processor (IMP). A store and forward packet switch which can accommodate up to four host computers.

b. Pluribus Interface Message Processor. A store and forward packet switch which can have in excess of 20 processors, depending on configuration, with each processor accommodating four host computers. This type IMP has a higher throughput capacity.

c. Terminal Interface Processor (TIP). A store and forward packet switch which can accomodate up to three host computers and 63 low speed asynchronous unintelligent terminals.

d. Host. A customer owned computer which is connected to a host port on an IMP or TIP.

(1) Local Host. A host located within 30 feet of an IMP or TIP.

(2) Distant Host. A host which is more than 30 feet but less than 2,000 feet from an IMP or TIP.

(3) Very Distant Host. A host which is located over 2,000 feet from an IMP or TIP and requires modems on its access line.

e. Terminal. A teletypewriter, CRT or similar unit which is connected to a terminal port of a TIP.

f. Interswitch Trunk. A circuit between packet switches (e.g., IMPS and TIPS) which is used to pass packets through the network.

g. Access Line. A circuit from a host computer or terminal to an IMP or TIP. The circuit may be a local cable or a transmission facility requiring modems.

h. ARPANET Backbone. The switching nodes (e.g., IMPS - TIPS), interfaces, the communications lines interconnecting the nodes, and the Network Control Center. The backbone is also known as the communications subnet.

i. Sponsor. A DoD or U.S. Government Agency, which qualifies as an ARPANET user, and is authorized to sponsor a contractor or other non-government activity for access to the ARPANET for the conduct of official U.S. Government business.

4. NETWORK DESCRIPTION

The ARPANET provides a capability for geographically separated computers (hosts) to communicate with each other. The host computers typically differ from one another in type, speed, word length, operating system, etc. Each host computer is connected into the network through a node which may be

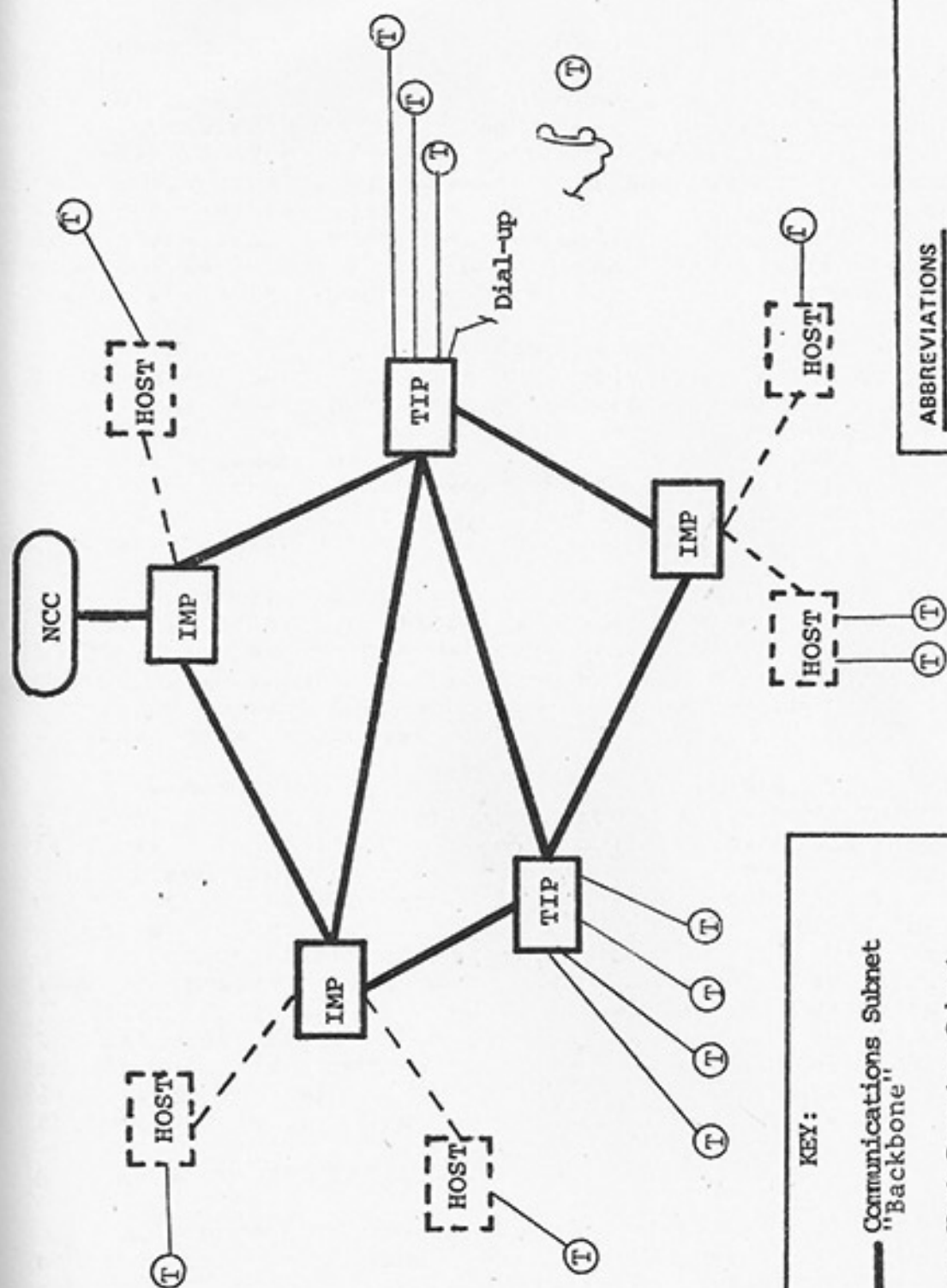
either an IMP or TIP that is normally located on its premises; a typical network is shown in Figure 1. The complete network is formed by interconnecting the nodes through wideband communication lines, normally 50,000 bits per second (50KBPS), supplied by common carriers. Each node is then programmed to store and forward messages to the neighboring nodes in the network. During a typical operation, a host passes a message to its node; this message is then passed from node to node through the network until it finally arrives at the destination IMP, which in turn passes it along to the destination host. This process normally takes less than 500 milli-seconds.

Hosts communicate with each other via regular messages. A regular message may vary in length from 96 up to 8159 bits, the first 96 of which are control bits called the leader. The leader is also used for sending control messages between the host and its IMP or TIP (node). The remainder of the message is the data, or the text.

For each regular message, the host specifies a destination, consisting of node, host and handling type. These three parameters uniquely specify a connection between source and destination hosts. The handling type gives the connection specific characteristics, such as priority or non-priority transmission. Additional leader space has been reserved for a fourth parameter, to be used in future inter-network addressing. For each connection, messages are delivered to the destination in the same order that they were transmitted by the source.

For each regular message, the host also specifies a 12-bit identifier, the message-ID. The message-ID, together with the destination of the message, is used as the "name" of the message. The node uses this name to inform the host of the disposition of the message. Therefore, if the host refrains from re-using a particular message-ID value (to a given destination) until the node has responded about that message-ID, messages will remain uniquely identified and the host can retransmit them in the event of a failure within the network.

After receiving a regular message from a host connected to it, a node breaks the message into several packets (currently the maximum data bits per packet is 1008) and passes these through the network in the direction of the destination. Eventually, when all packets arrive at the destination, they



ABBREVIATIONS

IMP-INTERFACE MESSAGE PROCESSOR
TIP-TERMINAL INTERFACE MESSAGE PROCESSOR
NCC-NETWORK CONTROL CENTER
HOST-HOST COMPUTER
T-TERMINAL

KEY:

Communications Subnet
"Backbone"
Host Computer Subnet
User Subnet

Figure 1 Conceptual Diagram of the ARPANET

are reassembled to form the original message which is passed to the destination host. The destination node returns a positive acknowledgment for receipt of the message to the source host. This acknowledgment is called a Ready for Next Message (RFNM) and identifies the message being acknowledged by name. In some relatively rare cases, however, the message may not be delivered due to a node failure; line disruption, etc., in such cases an Incomplete Transmission message will be returned to the source host instead of a RFNM. In this case the message which was incompletely transmitted is also identified by name.

If a response from the destination node (either RFNM or Incomplete Transmission) is not delivered to the originating host, this condition will be detected by the source node, which will automatically inquire of the destination node whether the original message was correctly received and repeat the inquiry until a response is received from the destination node. This inquiry mechanism is timeout-driven, and each timeout period may vary between 30 and 45 seconds in length.

When a message arrives at its destination node, the leader is modified to indicate the source host, but the message-ID field is passed through unchanged. Thus, in addition to providing message identification between a host and its local node, the message-ID can provide a means for hosts to identify messages between themselves.

The Network Control Center (NCC) for ARPANET is primarily concerned with the detection of line failures and IMP/TIP site failures. In addition, the NCC monitors the volumes of host traffic and line traffic which can give advance warning of network elements whose capacity may need to be increased and which can be used for site usage accounting. Also, the NCC keeps account of other data, such as sense switches, auto restart, memory protect settings etc., and buffer usage, for each IMP/TIP. This data is frequently helpful in diagnosing an IMP/TIP failure. Figure 2 is a typical example of the type of information which is generated by the NCC. Due to the constant monitoring of the ARPANET at the NCC, the percentage downtime for the network is very low (as illustrated in Figure 2).

5. NETWORK UTILIZATION POLICY

DCA approves new users for access to the ARPANET in addition to reviewing, on an annual basis, each user's qualification for service. The policy and procedures for ARPANET utilization are

NETWORK SUMMARY

Month	Line Outage	All* Causes	IMP DOWN		# of Nodes	AVERAGE HOST TRAFFIC	
			Percent	Hardware/Software MTBF		Internode	Intranode
July '75	.55%	.67%	.13	855	57	5,179,361	1,918,538
August	.54%	1.06%	.45	263	58	5,090,362	2,028,010
September	.47%	1.96%	.27	438	59	5,069,071	2,994,947
October	.46%	.58%	.24	482	60	5,097,670	3,773,602
November	.51%	.89%	.35	564	59	4,621,952	3,189,487
December	.91%	1:16%	.25	506	58	4,600,456	2,544,095
January '76	.48%	.93%	.56	468	57	5,483,506	2,700,853
February	.33%	.37%	.12	1082	57	5,743,145	1,887,597
March	.37%	.59%	.33	570	57	6,385,142	2,146,067
April	.25%	.49%	.12	760	57	6,082,436	2,712,229
May	.20%	.60%	.23	658	58	6,595,679	2,762,051
June	.40%	.32%	.11	684	58	7,276,809	2,778,634
July	.37%	.58%	.12	1514	58	6,627,968	1,961,726

*Includes P.M., site environmental problems, retrofits, etc.

Figure 2

as follows:

a. Responsibility for Operational Direction:

(1) The Director, DCA, will control system engineering and exercise operational direction over those operating elements of ARPANET which are part of the backbone. ARPANET user equipments/terminals are non-backbone facilities. However, ARPANET users must be responsive to management instructions issued by the DCA.

(2) Criteria and standards for interface are specified in Report Number 1822, Interface Message Processor: Specifications for the Interconnection of a host and an IMP (Bolt, Beranek and Newman, December 1975 revised periodically - AD-A018565. New criteria and standards developed jointly by the DCA, the Military Services, and the Defense agencies will be promulgated by the DCA. All users will meet ARPANET interface criteria.

(3) The Director, DCA on a continuing basis, will monitor the effectiveness of ARPANET, evaluate those matters which have major impact or will impact adversely on the network, and direct action to alleviate or prevent such impact.

b. User Access: The ARPANET is intended to be used solely for the conduct of or in support of official U.S. Government business.

(1) DoD Users - Subject to the availability of assets, DoD activities will be connected to the ARPANET provided their requirements are processed through normal communications validating channels.

(2) Non-DoD U.S. Government Activities - Requests for ARPANET service from non-DoD U.S. Government activities will be considered by DCA on a case-by-case basis.

(3) Non-Government U.S. Activities - A DoD or other U.S. Government activity authorized to use the network may sponsor, as a user, a non-government activity performing in contractual support of the U.S. Government. Justification outlining benefits to the U.S. Government for such access shall be provided to DCA by the sponsoring activity. Cost for network services provided to non-government activities shall be allocated to the sponsoring activity.

(4) Non-U.S. Activities - Non-U.S. activities will not be directly connected to the ARPANET. Access to the ARPANET may be provided through the facilities of an authorized user if coordinated with DCA.

(5) Non-Competitive Basis - The ARPANET is an operational DoD network and is not intended to compete with comparable commercial service. Accordingly, before ARPANET service is provided to any non-U.S. Government activity, it must be determined that adequate commercial service is not available.

(6) Privacy - The proposed use of the ARPANET must not violate applicable privacy laws.

c. Procedures:

(1) U.S. Government activities requesting ARPANET service must apply to the Director, Defense Communications Agency, ATTN: ARPANET Management Branch, Code 535.

(2) A non U.S. Government activity must have a U.S. Government activity acting as a sponsor. Application for service on the ARPANET must be submitted by the sponsoring activity to Director, Defense Communications Agency, ATTN: ARPANET Management Branch, Code 535. The application must clearly state how the proposed service is in the best interest of the U.S. Government, is essential to mission fulfillment, does not violate privacy laws and adequate commercial service is not available. The contract number of the contract between the sponsoring activity and the non-government activity requiring access to the ARPANET must be provided.

(3) Each application, government and non-government, will be in the format contained in Enclosure 3 and will contain the approximate amount of traffic to be passed, the hours of operation and concurrence from the agency whose IMP/TIP will be utilized as the ARPANET entry point.

(4) Requirements for wideband (50KBPS and above) circuits must be submitted six (6) months in advance, to give the contractor facility upgrading and circuit engineering time. All other requests for circuit leasing actions must be submitted sixty (60) days prior to the required service date to allow sufficient time for leasing actions.

(5) DCA will evaluate the application and advise the requesting activity of the disposition of their request within thirty (30) days. If the application is approved, the notification will include instructions for gaining access to the ARPANET.

6. NEW ARPANET SERVICE

a. Activities desiring to join the ARPANET which are qualified in accordance with the utilization policy will initiate contact with DCA (Code 535) as required by paragraph 5c. If terminal service only is required two connections are possible:

- o Hardwired to a TIP
- o Dial in to a TIP

If host service is required, three connections are possible:

- o Local host (within 30 feet of the IMP and TIP) Estimated cost \$3500 for the node interface
- o Distant Host (30 feet to 2000 feet) Estimated cost \$8000 for the node interface
- o Very distant host (over 2000 feet) Estimated cost \$5000 for the node interface

b. Steps to be taken and costs involved depend to a large extent on the present configuration of the net, the location of the new user and the service desired. For example, assume that an activity in the Washington, D.C. area wants to connect a host computer to the network and that activity does not own a node, i.e., IMP or TIP, in the area. It would send a request for service to DCA who would determine which node(s) in the area has the capacity to accomodate their requirement then advise them to request permission for a host connection from the owner of the node. If the node owner allows the connection, the host owner must reach an agreement with him on length of service and cost reimbursement.

c. The nonavailability of any host port is another possibility. This would necessitate that the host owner purchase a new IMP/TIP through DCA. Normally he would submit his requirement to DCA who would then process it through its contracting

office to the ARPANET hardware contractor. The new node would normally be funded by a Military Interdepartmental Purchase Request (MIPR). An IMP costs approximately \$60,000 and a TIP \$120,000 depending on configuration.

d. Host equipment, host interface hardware and software, host-to-IMP communications and site preparation are the responsibility of the user.

e. All communications lines (including VDH lines) will be ordered through the Defense Commercial Communications Office (DECCO) and will be processed by DCA with appropriate charges being billed to the user. Access line costs for planning purposes are contained in Enclosure 4.

f. Various services are provided to the ARPANET community to aid in the effective use of the network. Current available documentation includes:

- o Information on resources which are available at each host computer and the means to access this information. (Resource Handbook)
- o Network protocol information (Protocol Handbook)
- o Listing of individuals and hosts associated with the ARPANET (Directory)

g. The ARPANET itself (the communications subnet or "backbone") contains no security features for privacy or for the protection of classified defense information transiting the network. Therefore, it is the responsibility of those sponsors and users operating hosts in the network to take steps to protect information resident or accessible through their host computers from access by unauthorized users and to provide protection against unauthorized access to classified information which may reside or be accessible via their host computer link to the network.

h. There are no network "login" procedures; all access control is provided by the controls of the computers on the network.

i. DCA plans to use the ARPANET to test new concepts and developments, data communications and computer networking.

For such tests, interconnection of the ARPANET with other networks is authorized. DCA elements will coordinate their plans for testing with the DCA ARPANET operational manager (Code 530, Records Management Division). In a similar manner, DARPA is authorized to continue use of the ARPANET for testing new concepts and developments. DARPA will coordinate their plans for testing with the DCA ARPANET operational manager.

j. The Director, Telecommunications and Command and Control Systems (DTACCS) has expressed the following guidance for DoD Data Networks and their projected users:

"Those Military Department/Defense Agency ADP systems that are currently connected to the ARPANET or who plan on connecting to the ARPANET prior to the availability of AUTODIN II Phase I should configure their design so as to minimize the impact of reconnecting to AUTODIN II Phase I once this system is operational. The final disposition of the ARPANET will be determined at a later date."

7. ARPANET SPONSORS' GROUP

a. To be flexible and responsive to the requirements of the user community, an ARPANET Sponsors' Group has been established and chartered. The group enables sponsors of the network to consider and make recommendations to DCA on network operational activities and services provided by the network. It also provides a forum for the exchange of ideas and information on the operation of the ARPANET and future plans for the network of common interest to its sponsors.

b. The Sponsors' Group normally meets semi-annually. Special meetings may be called by the Chairman if the situation warrants attention to business prior to the next regularly scheduled meeting. Meetings normally are held in the Washington, D.C. area, but may be held at other locations.

8. FUNDING

a. The operation and maintenance (O&M) of the ARPANET backbone, i.e., nodes, interfaces, and inter-node communications circuits, is paid through the Communications Services Industrial Fund (CSIF) which is managed and operated by the Defense Communications Agency.

b. Under the working capital or revolving fund concept predetermined subscriber rates will be the basis for recovering the cost of operating and maintaining the Backbone network. The estimated cost to operate and maintain the ARPANET backbone during a fiscal year, divided by the estimated number of IMPS & TIPS in the network, provides the annual cost per year per node:

$$\frac{\text{Total O\&M Cost}}{\text{\#IMPS \& \#TIPS}} = \text{Annual Cost Per IMP or TIP.}$$

All ARPANET customer activities will be billed monthly based on a predetermined cost for each operational node in the Backbone. FY77 rate will be \$5900 per month per node + 1% overhead.

9. ARPANET INFORMATION

a. For further information on ARPANET write or call:

Defense Communications Agency
ATTN: Code 535
Telephone numbers (202) 692-6175/6 or AUTOVON
222-6175/6
ARPANET Mailbox: DCACode535@ISI

b. The following documents are published annually for the benefit of ARPANET users:

- (1) ARPANET RESOURCE HANDBOOK
- (2) ARPANET DIRECTORY
- (3) ARPANET PROTOCOL HANDBOOK (AD-A003 890)

These documents are distributed directly to ARPANET users. Other government agencies may receive copies by submitting a request with justification to DCA Code 535. Non-government agencies may procure copies from the

National Technical Information Service (NTIS)
U.S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161

c. Additional technical information is contained in

BBN Report 1822, Interface Message Processor, Specifications
For the Interconnection of a Host and an IMP - Revision 1975
(AD-A018 565) plus January 1976 Revision (AD-A019 160) and
a Selected Bibliography and Index to Publications About ARPANET
(AD-A026 900) which are also available from NTIS.

REQUIRED FORMAT FOR ARPANET SERVICE

- a. 19 March 1976 (Date request submitted).
- b. 1200 baud, full period, full duplex conditioned circuit (Type of service desired).
- c. Start (Type of request, may be a start, disconnect, or change).
- d. 19 May 1976 (Date service desired).
- e. Program Designator Code (This is a code required by Defense Commercial Communications Office (DECCO) indicating who will be billed for the service. If the sponsoring agency does not have a PDC, DCA will provide one upon request).
- f. Mr. William Jones (703) 123-4567 (Name and telephone number of contact at service point 1).
- Mr. John Smith (312) 123-4567 (Name and telephone number of contact at service point 2).
- g. Room 12, Building 418 University of Rochester 203 Smith Avenue Rochester, New York 12345 (Specific location where service is desired at service point 1).
- Rome Air Development Center Griffiss AFB, New York 12345 (Specific location where service is desired at service point 2).
- h. This paragraph will include any clarifying remarks deemed necessary to ensure full understanding of the service desired to include type of terminal or host. This paragraph will also include the information required by paragraphs 5c(2) and 5c(3).

Enclosure 3

ARPANET ACCESS LINE COST PLANNING

The following information may be used to determine estimated access line costs to connect terminals to a TIP or Very Distant Host computers to a TIP or IMP.

<u>ACCESS LINE RATE</u>	<u>MONTHLY SERVICE COST</u>	<u>ONE TIME INSTALLATION COST</u>
300 Baud and Less Modem	\$84 + 50¢/MI 12 EA	\$100 \$ 22 EA
301 to 1800 Baud Modem	\$84 + 50¢/MI 25	\$100 \$ 54 EA
2400 Baud Modem	\$84 + 50¢/MI 60	\$ 82 EA
4800 Baud Modem	\$84 + 50¢/MI 135	\$100 \$165 EA
9600 Baud Modem	\$100 + 50¢/MI 250	\$250 \$216 EA
50 Kilobit (Includes Modem)	920 + \$6/MI	\$450 EA

